Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

A Biological Survey of an Artificial Reef at French Creek, British Columbia

B.G. Naito

Department of Fisheries and Oceans
Habitat Management
South Coast Division
3225 Stephenson Point Road
Nanaimo, British Columbia V9T 1K3

March 1991

Canadian Manuscript Report of
Fisheries and Aquatic Sciences
No. 2100

Fisheries and Oceans Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

92-01160/

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2100

March 1991

A BIOLOGICAL SURVEY OF AN ARTIFICIAL REEF AT FRENCH CREEK, BRITISH COLUMBIA

by

B.G. Naito

Department of Fisheries and Oceans
Habitat Management
South Coast Division
3225 Stephenson Point Road
Nanaimo, British Columbia V9T 1K3

Minister of Supply and Services Canada 1991
Cat. No. Fs 97-4/2100E ISSN 0706-6473

Correct citation for this publication:

Naito, B.G. 1991. A biological survey of an artificial reef at French Creek, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2100:48p.

TABLE OF CONTENTS

List of Tables iv
List of Figures vi
List of Appendices vi
Acknowledgements vii
ABSTRACT/RESUME viii
1.0 INTRODUCTION 1
2.0 ASSESSMENT METHOD 1
3.0 RESULTS 4
3.1 Physical Habitat 4
3.2 Biological Characteristics 7
3.2.1 Fish 7
3.2.2 Macroinvertebrates 27
3.2.3 Macroalgae 33
3.3 Diel Changes 38
3.3.1 Fish 38
3.3.2 Macroinvertebrates 38
3.4 Seasonal Changes 40
3.4.1 Fish 40
3.4.2 Macroinvertebrates 42
3.4.3 Macroalgae 42
4.0 ACCURACY OF TRANSECT METHODS 42
5.0 DISCUSSION 43
6.0 REFERENCES 45

LIST OF TABLES

Table 1.	French Creek Artificial Reef Biological Survey Summary	1
Table 2.	Physical Dimensions of the French Creek Artificial Reef	5
Table 3.	November 1987 Day Dive Fish Species Counts at the French Creek Artificial Reef	8
Table 4.	November 1987 Day Dive Fish Biomass Estimates for the French Creek Artificial Reef	10
Table 5.	November 1987 Night Dive Fish Species Counts at the French Creek Artificial Reef	12
Table 6.	November 1987 Night Dive Fish Biomass Estimates for the French Creek Artificial Reef	14
Table 7.	March 1988 Day Dive Fish Species Counts at the French Creek Artificial Reef	15
Table 8.	March 1988 Day Dive Fish Biomass Estimates for the French Creek Artificial Reef	17
Table 9.	December 1988 Day Dive Fish Species Counts at the French Creek Artificial Reef	18
Table 10.	December 1988 Day Dive Fish Biomass Estimates for the French Creek Artificial Reef	20
Table 11.	June 1991 Day Dive Fish Species Counts at the French Creek Artificial Reef	21
Table 12.	June 1991 Day Dive Fish Biomass Estimates for the French Creek Artificial Reef	23
Table 13.	September 1991 Day Dive Fish Species Counts at the French Creek Artificial Reef	24
Table 14.	September 1991 Day Dive Fish Biomass Estimates for the French Creek Artificial Reef	26

LIST OF TABLES (cont'd)

Table 15. November 1987 Day Dive Invertebrate Species Counts for the French Creek Artificial Reef 28
Table 16. March 1988 Day Dive Invertebrate Species Counts for the French Creek Artificial Reef 29
Table 17. December 1988 Day Dive Invertebrate Species Counts for the French Creek Artificial Reef 31
Table 18. June 1991 Day Dive Invertebrate Species Counts for the French Creek Artificial Reef 32
Table 19. November 1987 Day Dive Macroalgae Species Observed on the French Creek Artificial Reef 34
Table 20. March 1988 Day Dive Macroalgae Species Observed on the French Creek Artificial Reef 35
Table 21. December 1988 Day Dive Macroalgae Species Observed on the French Creek Artificial Reef 36
Table 22. June 1991 Day Dive Macroalgae Species Observed on the French Creek Artificial Reef 37
Table 23. November 1987 Diel Changes in Fish at the French Creek Artificial Reef 39
Table 24. Seasonal Changes in Fish at the French Creek Artificial Reef 41

LIST OF FIGURES

Figure 1. Location of the Artificial Reef at French Creek, B.C. 2
Figure 2. A Diagrammatic Representation of the Artificial Reef at French Creek, B.C. 6

LIST OF APPENDICES

Appendix I. Species List For Fish Observed At The French Creek Artificial Reef 47
Appendix II. Species List For Invertebrates Observed At The French Creek Artificial Reef 48

ACKNOWLEDGEMENTS

The author would like to thank E.A. Appleton of Public Works Canada, Vancouver, B.C. for providing funding for a majority of this project. The author would also like to thank L.R. Russell of the Department of Fisheries and Oceans, Nanaimo, B.C. for reviewing the manuscript and for guidance and support throughout the project.

ABSTRACT

Naito, B.G. 1991. A biological survey of an artificial reef at French Creek, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2100:37p.

This survey describes the characteristics of an artificial reef near French Creek, British Columbia, in terms of its dimensions and structural complexity, and the distribution and abundance of fish, macroinvertebrates, and macroalgae it supports. Seasonal and diel changes in the pattern and degree of abundance of fish are also described using estimates for reef fish populations, density, and biomass.

RÉSUMÉ

Naito, B.G. 1991. A biological survey of an artificial reef at French Creek, British Columbia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2100:37p.

Le présent rapport décrit les caractéristiques d'un récif artificiel situé près de French Creek (Columbie-Britannique), soit ses dimensions et la complexité de sa structure, de même que la répartition et la quantité de poisson, de macroinvertébrés et de macroalgues qu'il soutient. On y décrit également les changements saisonniers et quotidiens de la composition et du degré d'abondance du poisson par des évaluations des populations de poisson, de la densité et de la biomasse du récif.

A BIOLOGICAL SURVEY OF AN ARTIFICIAL REEF AT FRENCH CREEK B.C.

1.0 INTRODUCTION

In the spring of 1984, Public Works Canada constructed an artificial reef to enhance marine fish habitat at French Creek, British Columbia. Two small rip rap groins were built as projections off the French Creek foreshore. Figure 1 shows the location of French Creek and the two rip rap groins. The rip rap groins extend subtidally perpendicular from shore and function as artificial reefs.

This report describes the biological surveys of one of the rip rap groins and assesses the use of artificial reefs by fish, invertebrates, and algae in southern British Columbia.

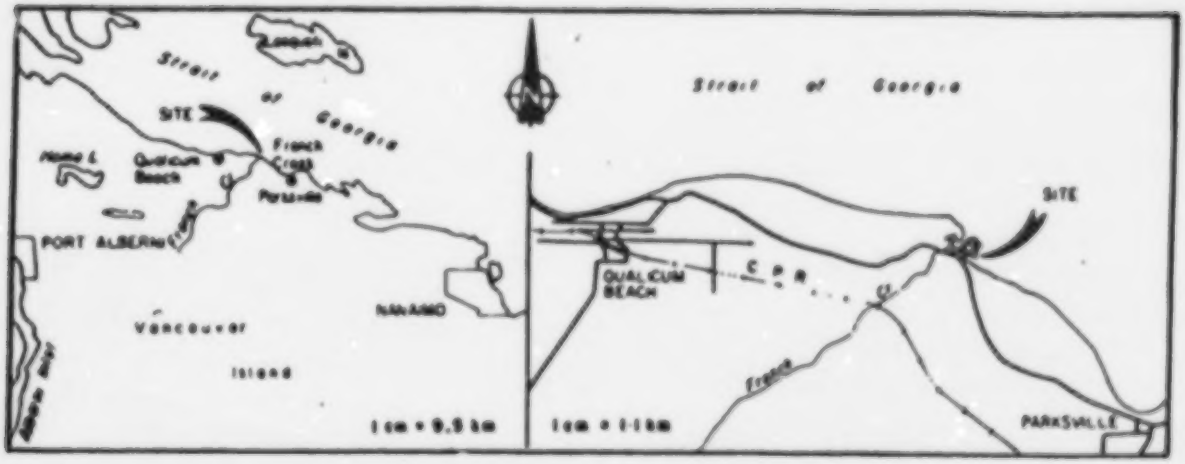
2.0 ASSESSMENT METHOD

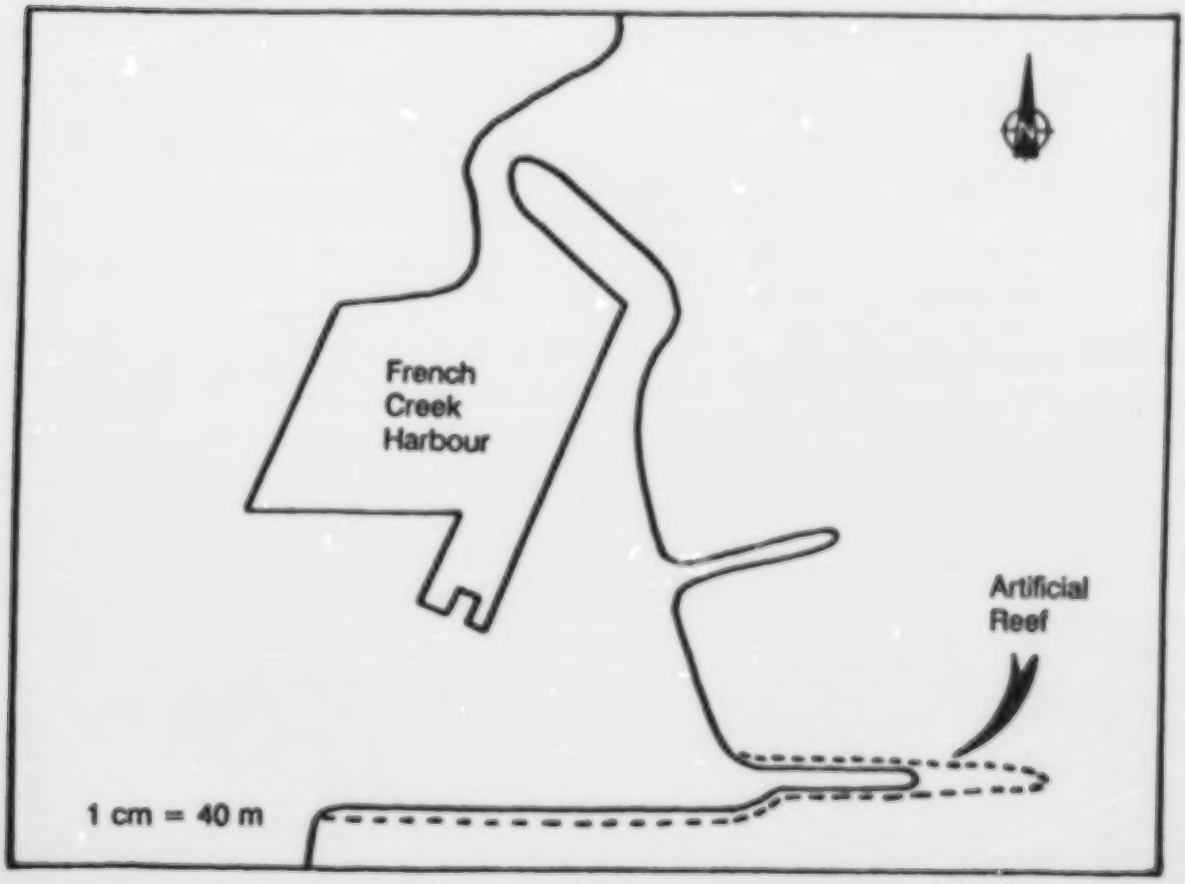
The reef was surveyed six times over a four year period. Table 1 summarizes the survey efforts.

Table 1. French Creek Artificial Reef
Biological Survey Summary

Dive Number	Date Surveyed	#Transects Surveyed	#SCUBA Dives	Time Surveyed
1	November 5, 1987	8	2	Day
2	November 17, 1987	4	1	Night
3	March 20, 1988	5	2	Day
4	December 8, 1988	4	1	Day
5	June 5, 1991	4	1	Day
6	September 12, 1991	4	1	Day

Figure 1. Location of the Artificial Reef at French Creek, B.C.





Biological surveys were conducted by underwater visual observations using SCUBA. SCUBA data was collected and recorded on plastic slates by two divers swimming along established transects. These transects were established as follows. One end of a weighted baseline was anchored with a brick at the base of the seaward end of the reef. This baseline was strung out along the base of the reef parallel to the reef's long axis. The other end of the baseline was anchored with a brick at the shoreward end of the reef. This line served as a starting point for transects positioned at regular intervals running perpendicular to the baseline and across the top of the reef. Fluorescent flagging tape was used on the baseline to mark the start of each transect.

Fish on the reef were observed by two methods. Fish occupying the water column over the reef (i.e. neritic fish) were observed using a method similar to that used by Richards et al. (1985). The abundance of neritic fish was recorded by observations made within a transect width that was dependent on visibility. Visibility was estimated by measuring the horizontal distance underwater from which a coloured disc can no longer be distinguished. The disc used was twenty four cm in diameter with alternating four cm wide brown coloured and four cm black bands. The size and colour of the disc was chosen to represent a copper rockfish so the measured distance will estimate the maximum distance at which a stationary copper rockfish can be seen by a SCUBA diver. Twice this distance was chosen as an estimate of transect width. Cryptic fish in reef crevices (i.e. benthic fish) were recorded by observing reef crevices within two metres on each side of each transect line.

Fish counts enumerated larger species such as perch, rockfish, lingcod, greenlings and large sculpins. Smaller, cryptic fish such as gobies and most sculpins were observed but not counted because representative counts were difficult to obtain.

Fish sizes were estimated to the nearest five cm by comparing fork lengths with a twenty cm rule marked on the plastic slates.

Invertebrates and macroalgae were observed within two metres on each side of the transect line. Invertebrate counts included large distinctive species such as seastars, crabs, and sea cucumbers. Smaller invertebrates were observed but not counted because obtaining representative counts was difficult. Only the abundance of the most conspicuous macroalgae was recorded. Abundance was determined by estimating the average percent cover within the depth range that each macroalgae type occupied on each transect.

The number of transects surveyed on each day of SCUBA diving is recorded in Table 1.

On the SCUBA dives occurring during the day, fish, macroinvertebrates, and macroalgae were surveyed. On the day SCUBA dives the lead diver clipped the transect line to the baseline and strung the transect line across the width of the reef while observing and recording swimming fish. On returning back to the baseline the lead diver searched out crevices within two metres on each side of the transect to observe and record hiding fish. The lead diver also recorded the distance from the baseline to the opposite side of the reef and the depth at the top of the reef.

The second diver recorded the depth at the start of each transect and swam along the transect line observing and recording invertebrates and macroalgae within two metres on each side of the transect. Once at the end of the transect line the second diver returned to the baseline while collecting the transect line. The diver then unclipped the transect line and carried it to the next starting point.

On the SCUBA dive conducted at night, only fish were surveyed. Methods of fish observation were the same as those employed during the day.

3.0 RESULTS

3.1 Physical Habitat

Physical dimensions of the French Creek artificial reef recorded during the SCUBA dive surveys are summarized in Table 2. Figure 2 is a diagrammatic interpretation of the reef.

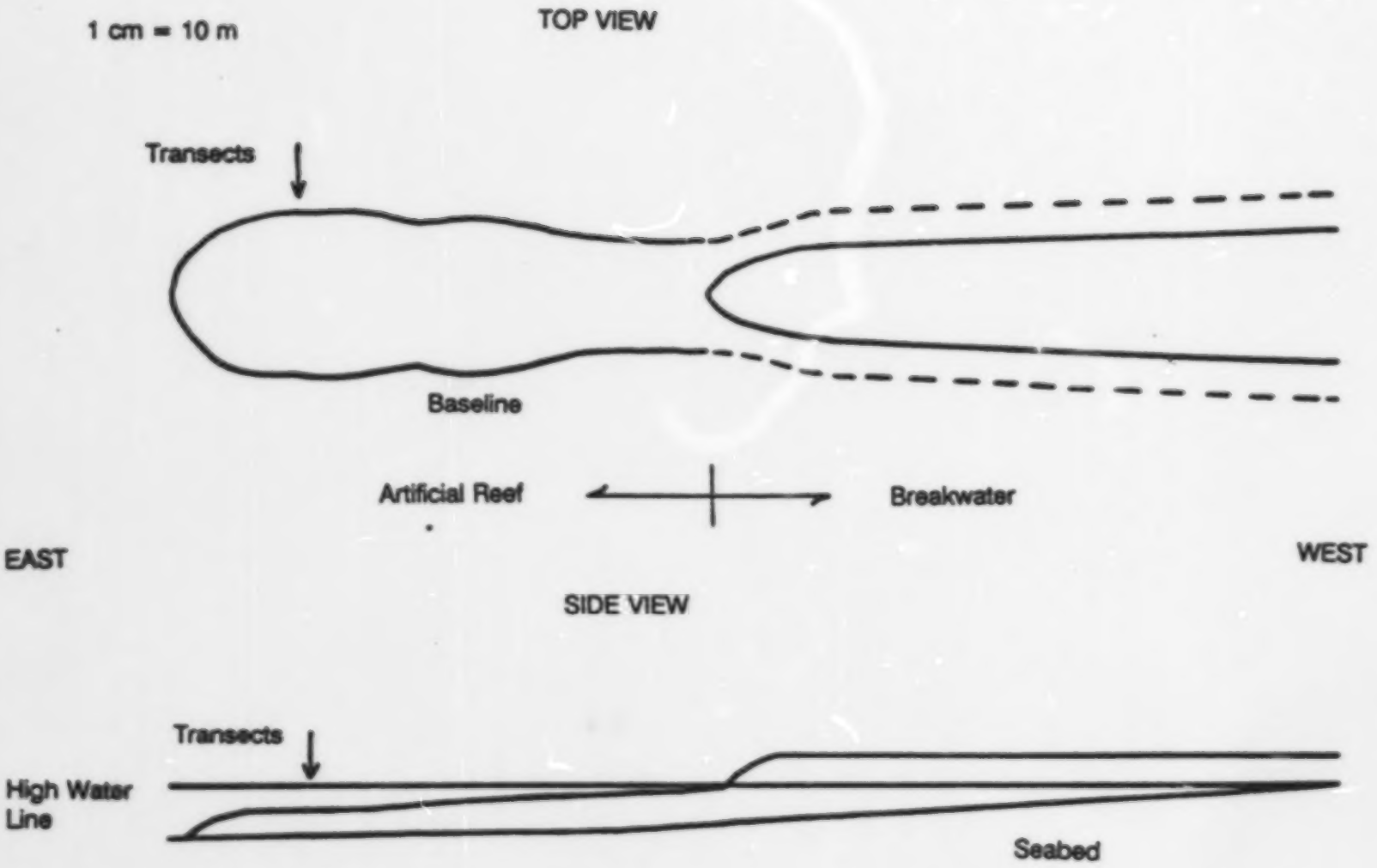
The base of the artificial reef is located from 6.7 to 9.0 m depth (relative of chart datum) on a gently sloping sand/silt substrate. The depth of the top of the reef at zero tide ranges from 0 to 4.0 m and the vertical relief of the reef ranges from 4.5 to 6.0 m. The reef measures approximately 88 m in length and averages 24.7 m wide. The footprint of the reef is estimated to be 2200 m .

The artificial reef is composed primarily of blasted rock, ranging from one to two metres in diameter. Most of the rocks have six sides with variable surface areas, with three sides usually exposed and three sides facing the interior of the reef. The shape of the rocks allows for considerable crevice space. Some smaller rocks, ranging from a third to one half metre in diameter, are wedged in the crevices between the larger rocks.

Table 2. Physical Dimensions of the French Creek Artificial Reef
Depths are given in metres relative to chart datum.

Survey Date	Baseline Distance (m)	Transect Length (m)	Reef Width (m)	Baseline Depth (m)	Height (m)	Clearance (m)
DEC0188	10	30.0	28.6	9.0	4.5	4.0
NOV0587	20	30.2	28.8	8.5	4.5	4.0
MAR2088	20	30.0	28.6	8.5	4.5	4.0
NOV0587	30	30.2	28.8	8.5	4.5	4.0
MAR2088	30	30.0	28.6	8.5	4.5	4.0
DEC0188	30	30.0	28.6	8.5	4.5	4.0
NOV0587	40	24.1	22.4	8.2	4.5	3.7
NOV0587	50	33.2	31.2	8.2	5.7	2.5
MAR2088	50	32.0	29.7	8.2	6.0	2.2
DEC0188	50	32.0	29.7	8.2	6.0	2.2
NOV0587	60	24.1	21.7	7.9	5.2	2.7
MAR2088	60	25.0	22.4	8.0	5.5	2.5
NOV0587	70	21.0	18.0	7.6	5.4	2.2
MAR2088	70	22.0	19.1	8.0	5.5	2.5
DEC0188	70	22.0	19.1	8.0	5.5	2.5
NOV0587	80	21.0	17.2	7.3	6.0	1.3
NOV0587	88	21.0	17.9	6.7	5.5	1.2
	Means	26.9	24.7	8.1	5.2	2.9

Figure 2. A Diagrammatic Representation of the Artificial Reef at French Creek, B.C.



3.2 Biological Characteristics

3.2.1 Fish

Reef fish population estimates were calculated from the transect surveys using the area density method, where the number of fish on the reef = (the area of the entire reef) x (the number of fish counted along the transects / the area of the transects).

November 1987 Day Survey

A summary of the day survey fish observations by transect and species is presented in Table 3.

During the November 1987 day dives the transect width, for benthic fish hiding in crevices, was set at four metres. The visual search area for all eight transects was, therefore, estimated to be 777 m or 35.3 % of the total reef area. For neritic fish on the day dives, the transect width was set at ten metres. The visual search area of all of eight transects was, therefore, estimated to be 1901 m or 86.3 % of the total reef area for these species.

During the daylight dives, striped perch (Embiotoca lateralis) were the most abundant species on the reef. Copper rockfish (Sebastes caurinus) were estimated to be the second most common species followed by surf perch (Rhacochilus vacca), kelp greenlings (Hexagrammus decagrammus), quillback rockfish (Sebastes maliger), lingcod (Ophiodon elongatus), painted greenlings (Oxylebius pictus), large sculpins (Family Cottidae), and shiner perch (Cymatogaster aggregata).

Table 3. November 1987
Day Dive Fish Species Counts at the French Creek Artificial Reef

Estimated Total Number Of Fish On The Reef = 418.5

Cryptic Fish	Baseline Distance (m)								Total	Fish per	Estimated	% of Total
	20	30	40	50	60	70	80	88	Observed	100 m^2	Total On Reef	Fish On Reef
Sculpins												
Brown Irish Lord	0	0	0	0	0	0	1	0	1	0.1	2.8	0.7
Red Irish Lord	0	0	0	0	0	1	0	0	1	0.1	2.8	0.7
Rockfish												
Juvenile Copper Rockfish	3	2	4	0	1	4	2	3	19	2.4	53.8	12.9
Adult Copper Rockfish	1	0	1	1	1	0	0	0	4	0.5	11.3	2.7
Juvenile Quillback Rockfish	2	0	0	0	0	0	0	0	2	0.3	5.7	1.4
Adult Quillback Rockfish	0	0	1	0	0	0	0	0	1	0.1	2.8	0.7
Greenlings												
Juvenile Kelp Greenling	1	0	0	0	0	1	1	0	3	0.4	8.5	2.0
Adult Kelp Greenling	0	0	0	1	1	0	0	0	2	0.3	5.7	1.4
Painted Greenling	0	0	0	0	0	0	1	1	2	0.3	5.7	1.4
Total	7	2	6	2	3	6	5	4	35	4.5	99.1	23.7
Survey Area (m^2)	121	121	96	133	96	84	84	42	777			
Fish / 100 m^2	5.8	1.7	6.3	1.5	3.1	7.1	6.0	9.5	4.5			

Swimming Fish	Baseline Distance (m)								Total	Fish per	Estimated	% of Total
	20	30	40	50	60	70	80	88	Observed	100 m^2	Total On Reef	Fish On Reef
Greenlings												
Juvenile Lingcod	0	0	1	0	0	0	0	0	1	0.1	1.2	0.3
Adult Lingcod	1	1	0	0	0	1	0	1	4	0.2	4.6	1.1
Perch												
Shiner Perch	0	0	0	1	0	0	0	0	1	0.1	1.2	0.3
Striped Perch	20	36	33	55	2	40	8	54	249	13.1	288.2	68.9
Surf (Pile) Perch	0	0	0	2	6	3	0	10	21	1.1	24.3	5.8
Total	21	37	34	58	8	44	8	65	276	14.5	319.4	76.3
Survey Area (m^2)	302	302	241	332	241	210	189	84	1901			
Fish / 100 m^2	7.0	12.3	14.1	17.5	3.3	21.0	4.8	77.4	14.5			

Note: The striped perch data for transects 7 and 8 have been adjusted to reflect the fact that the transects o
(i.e. transect width = 5 m and transects 7 and 8 are only 8 m apart)

Striped perch were almost always observed in schools on the reef. Each school consisted of fish ranging from ten to thirty cm in length. Surf perch were observed swimming in groups of two to ten fish. The surf perch in each group ranged from five to fifteen cm in length. Four of the lingcod observed were adults ranging from fifty-five to sixty-five cm in length while one was a juvenile of twenty cm length. All other fish observed were benthic fish hiding in crevices. Nineteen of the twenty-three copper rockfish seen were juveniles ranging from seven to twelve cm in length. The remainder of the copper rockfish were adults ranging from twenty-five to thirty cm. Three of the five kelp greenlings observed were juveniles fifteen to twenty cm long, while the other two were adults twenty-five to thirty cm in length. Of the three quillback rockfish observed, two were juveniles, averaging thirteen cm in length, and one was an adult of twenty-five cm. The two painted greenlings were adults of about twenty cm long. The two large sculpins observed were about twenty cm in length while the one shiner perch counted was ten cm long.

During the November 1987 day survey, of the total fish estimated on the reef, 76% were neritic fish while 24% were benthic fish.

Day dive fish biomass estimates for the French Creek artificial reef are provided in Table 4.

During the day dives, striped perch accounted for the largest fish biomass. Lingcod represented the second greatest biomass followed by copper rockfish, kelp greenlings, painted greenlings, surf perch, quillback rockfish, large sculpins, and shiner perch.

In summary, three species of perch, Family Embiotocidae, account for 75% of the reef fish population and 44% of the biomass. Of the three species of perch, striped perch were the most abundant numerically, accounting for 69% of the total reef fish population and accounting for 41% of the total fish biomass. Three species of greenlings, Family Hexagrammidae, accounted for only 6% of the reef fish population but accounted for 37% of the fish biomass on the reef. Of the three species of greenlings, kelp greenlings were the most numerous providing 3.5% of the total reef fish population while lingcod accounted for the most biomass providing 29% of the reef total. Copper rockfish accounted for 15.5% of the reef fish population and 14% of the reef fish biomass. Large sculpins accounted for only 1.5% of the reef fish population and only 2.5% of the reef fish biomass.

Table 4. November 1987
Day Dive Fish Biomass Estimates for the French Creek Artificial Reef

Fish Type	Estimated Total On Reef	Average Size (cm)	Average Weight (kg)	Total Biomass (kg)	% of Total Biomass On Reef
Sculpins					
Brown Irish Lord	2.8	20	0.16	0.4	1.3
Red Irish Lord	2.8	20	0.16	0.4	1.3
Rockfish					
Juvenile Copper Rockfish	53.8	10	0.02	1.1	3.1
Adult Copper Rockfish	11.3	30	0.34	3.8	10.9
Juvenile Quillback Rockfish	5.7	15	0.05	0.3	0.8
Adult Quillback Rockfish	2.8	25	0.23	0.6	1.8
Greenlings					
Juvenile Kelp Greenlings	8.5	20	0.05	0.4	1.2
Adult Kelp Greenlings	5.7	30	0.19	1.1	3.1
Juvenile Lingcod	1.2	30	0.24	0.3	0.8
Adult Lingcod	4.6	60	2.15	9.9	28.1
Painted Greenling	5.7	30	0.24	1.4	3.9
Perch					
Shiner Perch	1.2	10	0.01	0.0	0.0
Striped Perch	288.2	15	0.05	14.4	40.9
Surf Perch	24.3	10	0.04	1.0	2.8
Total	418.5	-	-	35.2	100.0

Note: Average weights for perch were calculated using data from Walton (1979).
Average weights for rockfish, greenlings, and sculpins were calculated using formulas provided by C. Hand (Dept. Fisheries and Oceans, pers. comm.).

November 1987 Night Survey

A summary of night dive fish observations by transect and species is presented in Table 5.

During the night dive the transect width was set at four metres for benthic fish hidden in crevices, therefore, the visual search area for the four surveyed transects was estimated to be 397 m or 18% of the total reef area. For neritic fish swimming over the reef the transect width was set at six metres equating the visual search area for all four transects to be 597 m or 27% of the total reef area.

During the night survey, copper rockfish were estimated to be the most abundant species on the reef. Striped perch were estimated to be the second most common species on the reef followed by surf perch, quillback rockfish, kelp greenlings, large sculpins and lingcod.

Approximately half of the total number of copper rockfish on the reef were subadults averaging fifteen cm in length, while the other half were adults with an average length of twenty-five cm. Copper rockfish were observed both as benthic and neritic. The majority of the juveniles and over 60% of the adult copper rockfish were observed as benthic, hiding in crevices. The striped perch on the reef, averaging twenty-five cm in length, were observed either singly or in small schools not exceeding five individuals. Striped perch were seen both as benthic and neritic, but it is estimated that over 60% of the fish counted exhibited the latter behaviour. The surf perch on the reef, averaged twenty cm and were observed individually either as benthic or neritic. The majority of the surf perch, however, were hidden in crevices. Approximately half of the quillback rockfish on the reef were subadults or juveniles, averaging fifteen cm in length, while the remaining were adults with an average length of twenty-five cm. All of the adult quillback rockfish and a majority of the juveniles were observed in crevices. A few quillback rockfish juveniles were observed swimming over the reef. Adult kelp greenling, averaged thirty cm in length, and were always seen hiding in crevices. No juvenile kelp greenling were noted on the night dive. The large sculpins seen on the reef averaged twenty cm long and were all observed in crevices. All of the lingcod counted were adults, averaging sixty cm in length, and were generally found resting on the reef.

During the night dive survey 24% of the estimated number of fish on the reef were observed as neritic, while the remainder were benthic seen hiding in crevices.

Table 5. November 1987
Night Dive Fish Species Counts at the French Creek Artificial Reef

Estimated Total Number Of Fish On The Reef = 878.7

Cryptic Fish	Baseline Distance (m)				Total	Fish per	Estimated	% of Total
	20	40	60	80	Observed	100 m^2	Total On Reef	Fish On Reef
Sculpins								
Brown Irish Lord	0	1	0	0	1	0.3	5.5	0.6
Red Irish Lord	3	0	1	1	5	1.3	27.7	3.2
Rockfish								
Juvenile Copper Rockfish	14	16	4	8	42	10.6	232.7	26.5
Adult Copper Rockfish	9	6	9	3	27	6.8	149.6	17.0
Juvenile Quillback Rockfish	4	0	1	1	6	1.5	33.2	3.8
Adult Quillback Rockfish	4	3	1	0	8	2.0	44.3	5.0
Greenlings								
Juvenile Kelp Greenling	0	0	0	0	0	0.0	0.0	0.0
Adult Kelp Greenling	0	3	0	4	7	1.8	38.8	4.4
Painted Greenling	0	0	0	0	0	0.0	0.0	0.0
Perch								
Shiner Perch	0	0	0	0	0	0.0	0.0	0.0
Striped Perch	2	0	6	0	8	2.0	44.3	5.0
Surf Perch	0	7	1	8	16	4.0	88.7	10.1
Total	36	36	23	25	120	30.2	665.0	75.7
Survey Area (m^2)	121	96	96	84	397			
Fish / 100 m^2	29.8	37.5	24.0	29.8	30.2			

Swimming Fish	Baseline Distance (m)				Total	Fish per	Estimated	% of Total
	20	40	60	80	Observed	100 m^2	Total On Reef	Fish On Reef
Rockfish								
Juvenile Copper Rockfish	5	2	2	0	9	1.5	33.2	3.8
Adult Copper Rockfish	8	8	7	1	24	4.0	88.4	10.1
Juvenile Quillback Rockfish	2	0	0	0	2	0.3	7.4	0.8
Adult Quillback Rockfish	0	0	0	0	0	0.0	0.0	0.0
Greenlings								
Juvenile Lingcod	0	0	0	0	0	0.0	0.0	0.0
Adult Lingcod	0	1	1	0	2	0.3	7.4	0.8
Perch								
Shiner Perch	0	0	0	0	0	0.0	0.0	0.0
Striped Perch	4	6	4	5	19	3.2	70.0	8.0
Surf (Pile) Perch	0	0	2	0	2	0.3	7.4	0.8
Total	19	17	16	6	58	9.7	213.7	24.3
Survey Area (m^2)	181	145	145	126	597			
Fish / 100 m^2	10.5	11.7	11.0	4.8	9.7			

Night survey fish biomass estimates for the French Creek artificial reef are provided in Table 6.

During the night dive, copper rockfish represented the largest fish biomass to the reef. Striped perch provided the second greatest biomass followed by surf perch, lingcod, quillback rockfish, kelp greenling, and large sculpins.

In summary, the two rockfish species, Family Sebastes, accounted for 67% of the total reef fish population and 56% of the total reef fish biomass. Copper rockfish accounted for 57% of the total reef fish population and 49% of the total reef fish biomass. Quillback rockfish accounted for 10% of the estimated total fish population and 7% of the total fish biomass on the reef. The two species of perch, Family Embiotocidae, accounted for 24% of the total fish and 27% of the total fish biomass on the reef. Striped perch accounted for 13% of the total reef fish population and 17% of the fish biomass while surf perch accounted for 11% of the total number of fish on the reef and 10% of the fish biomass. Two species of greenling, Family Hexagramidae, accounted for over 5% of the reef fish population and 15% of the fish biomass. Of the two species of greenling, kelp greenling were the most abundant providing over 4% of the reef fish population while lingcod accounted for the most biomass providing over 9% of the total fish biomass. Large sculpins accounted for less than 4% of the reef fish population and less than 3% of the total reef fish biomass.

March 1988 Day Survey

A summary of fish observations by transect and species during the March 1988 day survey is presented in Table 7.

During the dive survey, the transect width for benthic fish was set at four metres, therefore, the visual search area for the five transects surveyed was estimated to be 556 m or 25% of the total reef area. For neritic fish the transect width was set at ten metres, therefore, the visual search area of the five transects surveyed totalled 1390 m or 62% of the total reef area.

During these observations, striped perch were the most abundant species on the reef. Surf perch were the second most abundant species followed by cabezons (Scorpaenichthys marmoratus) and lingcod.

Table 6. November 1987
Night Dive Fish Biomass Estimates for the French Creek Artificial Reef

Fish Type	Estimated Total On Reef	Average Size (cm)	Average Weight (kg)	Total Biomass (kg)	% of Total Biomass On Reef
Sculpins					
Brown Irish Lord	5.5	20	0.16	0.9	0.5
Red Irish Lord	27.7	15	0.14	3.9	2.3
Rockfish					
Juvenile Copper Rockfish	265.9	15	0.07	18.6	10.9
Adult Copper Rockfish	238.0	25	0.27	64.3	37.6
Juvenile Quillback Rockfish	40.6	15	0.05	2.0	1.2
Adult Quillback Rockfish	44.3	25	0.23	10.2	6.0
Greenlings					
Juvenile Kelp Greenlings	0.0	0	0.00	0.0	0.0
Adult Kelp Greenlings	38.8	30	0.24	9.3	5.4
Juvenile Lingcod	0.0	0	0.00	0.0	0.0
Adult Lingcod	7.4	60	2.15	15.9	9.3
Painted Greenling	0.0	0	0.00	0.0	0.0
Perch					
Shiner Perch	0.0	0	0.00	0.0	0.0
Striped Perch	114.3	25	0.25	28.6	16.7
Surf Perch	96.1	20	0.18	17.3	10.1
Total	878.7	-	-	170.9	100.0

Note: Average weights for perch were calculated using data from Walton (1979).
Average weights for rockfish, greenlings, and sculpins were calculated using formulas provided by C. Hand (Dept. Fisheries and Oceans, pers. comm.).

Table 7. March 1988
Day Dive Fish Species Counts at the French Creek Artificial Reef

Estimated Total Number Of Fish On The Reef = 278.5

Cryptic Fish	Baseline Distance (m)					Total	Fish per	Estimated	% of Total
	20	30	50	60	70	Observed	100 m^2	Total On Reef	Fish On Reef
Sculpins									
Cabezon	1	0	1	0	0	2	0.4	7.9	2.8
Total	1	0	1	0	0	2	0.4	7.9	2.8
Survey Area (m^2)	120	120	128	100	88	556			
Fish / 100 m^2	0.8	0.0	0.8	0.0	0.0	0.4			

Swimming Fish	Baseline Distance (m)					Total	Fish per	Estimated	% of Total
	20	30	50	60	70	Observed	100 m^2	Total On Reef	Fish On Reef
Greenlings									
Adult Lingcod	0	0	0	0	1	1	0.1	1.6	0.6
Perch									
Striped Perch	5	75	8	50	7	145	10.4	229.5	82.4
Surf (Pile) Perch	25	0	0	0	0	25	1.8	39.6	14.2
Total	30	75	8	50	8	171	12.3	270.6	97.2
Survey Area (m^2)	300	300	320	250	220	1390			
Fish / 100 m^2	10.0	25.0	2.5	20.0	3.6	12.3			

Striped perch were nearly always observed in schools. Each school of variable numbers of individuals consisted of fish ranging from fifteen to twenty five cm in length. One large school of surf perch, with individuals ranging from five to fifteen cm, was also noted swimming over the reef. Only one lingcod, sixty cm long, was observed. The cabezons seen were approximately thirty cm in length and were found hiding in crevices.

During the survey, 97% of the total number of fish estimated on the reef were neritic while 3% were benthic fish.

Fish biomass estimates for the March 1988 day survey are provided in Table 8.

During the survey striped perch accounted for the most fish biomass on the reef. Lingcod contributed the second greatest percentage of fish biomass followed by surf perch and large sculpins.

In summary, two perch species, Family Embiotocidae, accounted for 97% of the total reef fish population and 74% of the biomass. Of the two species of perch, striped perch were the most abundant in number, accounting for 82% of the total reef fish population and, for 65% of the total fish biomass. Surf perch accounted for 14% of the total reef fish population and 9% of the total fish biomass. Lingcod represented less than 1% of the total reef fish population but accounted for 19% of the total biomass. Cabezons accounted for 3% of the fish population and 7% of the fish biomass.

December 1988 Day Survey

A summary of fish observations by transect and species during the December 1988 day survey is presented in Table 9.

During the survey the transect width, for benthic fish hidden in crevices, was set at two metres, therefore, the visual search area for all four transects was estimated to be 230 m or 11% of the total reef area. For neritic fish swimming over the reef the transect width was set at six metres which equated to a visual search area for the four transects of 684 m or 31% of the total reef area.

Striped perch were the most abundant species on the reef, followed by lingcod and painted greenlings.

Table 8. March 1988
Day Dive Fish Biomass Estimates for the French Creek Artificial Reef

Fish Type	Estimated Total On Reef	Average Size (cm)	Average Weight (kg)	Total Biomass (kg)	% of Total Biomass On Reef
Sculpins					
Cabezon	7.9	20	0.16	1.3	7.1
Greenlings					
Lingcod	1.6	60	2.15	3.4	19.4
Perch					
Striped Perch	229.5	15	0.05	11.5	64.6
Surf (Pile) Perch	39.6	10	0.04	1.6	8.9
Total	278.5	-	-	17.8	100.0

Note: Average weights for perch were calculated using data from Walton (1979).
Average weights for rockfish, greenlings, and sculpins were calculated using formulas provided by C. Hand (Dept. Fisheries and Oceans, pers. comm.).

Table 9. December 1988
Day Dive Fish Species Counts at the French Creek Artificial Reef

Estimated Total Number Of Fish On The Reef = 649.7

No Cryptic Fish Observed.

Swimming Fish	Baseline Distance (m) 10	30	50	70	Total Observed	Fish per 100 m^2	Estimated Total On Reef	% of Total Fish On Reef
Greenlings								
Adult Lingcod	0	0	0	1	1	0.1	3.2	0.5
Painted Greenling	0	0	0	1	1	0.1	3.2	0.5
Perch								
Striped Perch	65	35	50	50	200	29.2	643.3	99.0
Total	65	35	50	52	202	29.5	649.7	100.0
Survey Area (m^2)	180	180	192	132	684			
Fish / 100 m^2	36.1	19.4	26.0	39.4	29.5			

Striped perch were observed in schools ranging in size from five to fifty fish. Each school consisted of fish of various sizes, ranging from fifteen to twenty-five cm in length. Only one lingcod seventy-five cm long and one painted greenling of twenty-five cm were observed on the reef.

During the survey, all fish were noted as neritic and none were observed as benthic hiding in crevices.

Fish biomass estimates for the December 1988 survey are provided in Table 10.

Striped perch accounted for the largest percentage of the total fish biomass on the reef. Lingcod contributed the second greatest amount of fish biomass followed by painted greenlings.

In summary, striped perch accounted for 99% of the total reef fish population and 81% of the total biomass. Lingcod accounted for less than 1% of the total reef fish population and 18% of the total biomass. Painted greenlings accounted for less than 1% of the fish population and only 1% of the biomass.

June 1991 Day Survey

A summary of the day survey fish observations by transect and species is presented in Table 11.

During the June 1991 survey the transect width, for benthic fish hiding in crevices, was set at two metres. The visual search area for all four transects was, therefore, estimated to be 231 m or 10.5% of the total reef area. For neritic fish on the day dives, the transect width was set at four metres. The visual search area of the four transects was, therefore, estimated to be 462 m or 5.3% of the total reef area for neritic species.

During the daylight dives, quillback rockfish were the most abundant species on the reef. Surf perch were estimated to be the second most common species followed by, copper rockfish, lingcod, and striped perch.

Table 10. December 1988
Day Dive Fish Biomass Estimates for the French Creek Artificial Reef

Fish Type	Estimated Total On Reef	Average Size (cm)	Average Weight (kg)	Total Biomass (kg)	% of Total Biomass On Reef
Greenlings					
Lingcod	3.2	75	2.25	7.2	18.0
Painted Greenling	3.2	25	0.17	0.5	1.4
Perch					
Striped Perch	643.3	15	0.05	32.2	80.6
Total	649.7	-	-	39.9	100.0

Note: Average weights for perch were calculated using data from Walton (1979).
Average weights for rockfish, greenlings, and sculpins were calculated using formulas provided by C. Hand (Dept. Fisheries and Oceans, pers. comm.).

Table 11. June 1991

Day Dive Fish Species Counts at the French Creek Artificial Reef

Estimated Total Number Of Fish On The Reef = 123.8

Cryptic Fish	Baseline Distance (m)				Total	Fish per	Estimated	% of Total
	20	40	50	70	Observed	100 m^2	Total On Reef	Fish On Reef
Rockfish								
Juvenile Copper Rockfish	0	1	0	0	1	0.4	9.5	7.7
Adult Copper Rockfish	0	1	0	0	1	0.4	9.5	7.7
Juvenile Quillback Rockfish	1	0	1	0	2	0.9	19.0	15.4
Adult Quillback Rockfish	0	3	0	0	3	1.3	28.6	23.1
Total	1	5	1	0	7	3.0	66.7	53.9
Survey Area (m^2)	60	50	70	51	231			
Fish / 100 m^2	1.7	10.0	1.4	0.0	3.0			

Swimming Fish	Baseline Distance (m)				Total	Fish per	Estimated	% of Total
	20	40	50	70	Observed	100 m^2	Total On Reef	Fish On Reef
Rockfish								
Juvenile Copper Rockfish	0	0	0	0	0	0.0	0.0	0.0
Adult Copper Rockfish	0	0	0	0	0	0.0	0.0	0.0
Juvenile Quillback Rockfish	0	0	0	0	0	0.0	0.0	0.0
Adult Quillback Rockfish	0	1	0	2	3	0.6	14.3	11.5
Greenlings								
Juvenile Lingcod	1	0	0	0	1	0.2	4.8	3.8
Adult Lingcod	1	0	0	0	1	0.2	4.8	3.8
Perch								
Striped Perch	0	0	2	0	2	0.4	9.5	7.7
Surf (Pile) Perch	0	0	0	5	5	1.1	23.8	19.2
Total	2	1	2	7	12	2.6	57.1	46.2
Survey Area (m^2)	120	100	140	102	462			
Fish / 100 m^2	1.7	1.0	1.4	6.9	2.6			

Quillback rockfish were observed swimming over the reef and hiding in reef crevices. Of the eight quillback rockfish observed, two were juveniles, averaging thirteen cm in length and found in crevices, while six were adults averaging twenty-five cm with half the adults observed in crevices and the other half observed swimming over the reef. Surf perch were observed swimming in a groups of five fish. The surf perch in each group ranged from five to fifteen cm in length. One of the copper rockfish observed was a juvenile of about ten cm in length. The other copper rockfish observed was an adult of about twenty-five cm. One of the two lingcod observed was an adult of about fifty cm in length while the other one was a juvenile of twenty cm length. The two striped perch observed were found in a pair on the reef. The surf perch ranged from twenty to thirty cm in length.

During the June 1991 survey, of the total fish estimated on the reef, 46.2% were neritic fish while 53.9% were benthic fish.

Day dive fish biomass estimates for the French Creek artificial reef are provided in Table 12.

During the dive survey, lingcod accounted for the largest fish biomass. Quillback rockfish represented the second greatest biomass followed by copper rockfish, surf perch, and striped perch.

In summary, rockfish, Family Sebastes, accounted for 65% of the reef fish population and 53% of the biomass. Of the two species of rockfish, quillback rockfish were the most abundant numerically, accounting for 50% of the total reef fish population and accounting for 40% of the total fish biomass. Copper rockfish accounted for 15.5% of the reef fish population and 12.5% of the reef fish biomass. Two species of perch, Family Embiotocidae, accounted for 27% of the reef fish population but only accounted for 4.5% of the fish biomass on the reef. Lingcod accounted for 7.5% of the total reef fish population and 42% of the total fish biomass on the reef.

September 1991 Day Survey

A summary of the day survey fish observations by transect and species is presented in Table 13.

During the September 1991 survey the transect width, for benthic fish hiding in crevices, was set at two metres. The visual search area for all four transects was, therefore, estimated to be 200 m or 10.0% of the total reef area. For neritic fish on the day dives, the transect width was set at six metres. The visual search area of all of eight transects was, therefore, estimated to be 610 m or 27.7% of the total reef area.

Table 12. June 1991
Day Dive Fish Biomass Estimates for the French Creek Artificial Reef

Fish Type	Estimated Total On Reef	Average Size (cm)	Average Weight (kg)	Total Biomass (kg)	% of Total Biomass On Reef
Rockfish					
Juvenile Copper Rockfish	9.5	10	0.02	0.2	0.7
Adult Copper Rockfish	9.5	30	0.34	3.2	11.9
Juvenile Quillback Rockfish	19	15	0.05	1.0	3.5
Adult Quillback Rockfish	42.9	25	0.23	9.9	36.4
Greenlings					
Juvenile Lingcod	4.8	30	0.24	1.2	4.2
Adult Lingcod	4.8	60	2.15	10.3	38.0
Perch					
Striped Perch	9.5	15	0.05	0.5	1.8
Surf Perch	23.8	10	0.04	1.0	3.5
Total	123.8	-	-	27.1	100.0

Note: Average weights for perch were calculated using data from Walton (1979).
Average weights for rockfish, greenlings, and sculpins were calculated using formulas provided by C. Hand (Dept. Fisheries and Oceans, pers. comm.).

Table 13. September 1991
Day Dive Fish Species Counts at the French Creek Artificial Reef

Estimated Total Number Of Fish On The Reef = 553.6

Cryptic Fish	Baseline Distance (m) 20	40	60	80	Total Observed	Fish per 100 m^2	Estimated Total On Reef	% of Total Fish On Reef
Rockfish								
Juvenile Copper Rockfish	0	0	0	0	0	0.0	0.0	0.0
Adult Copper Rockfish	1	0	0	0	1	0.5	11.0	2.0
Juvenile Quillback Rockfish	0	0	1	0	1	0.5	11.0	2.0
Adult Quillback Rockfish	0	1	6	0	7	3.5	77.0	13.9
Greenling								
Kelp Greenling	0	1	0	0	1	0.5	11.0	2.0
Total	1	2	7	0	10	5	110.0	19.9
Survey Area (m^2)	60	48	50	42	200			
Fish / 100 m^2	1.7	4.2	14.0	0.0	5.0			

Swimming Fish	Baseline Distance (m) 20	40	60	80	Total Observed	Fish per 100 m^2	Estimated Total On Reef	% of Total Fish On Reef
Rockfish								
Juvenile Copper Rockfish	0	0	0	0	0	0.0	0.0	0.0
Adult Copper Rockfish	0	0	0	0	0	0.0	0.0	0.0
Juvenile Quillback Rockfish	0	0	1	0	1	0.2	3.6	0.7
Adult Quillback Rockfish	0	0	0	0	0	0.0	0.0	0.0
Greenlings								
Adult Lingcod	1	1	0	0	2	0.3	7.2	1.3
Kelp Greenling	5	2	4	4	15	2.5	54.1	9.8
Perch								
Striped Perch	0	2	15	32	49	8.0	176.7	31.9
Surf (Pile) Perch	0	20	5	31	56	9.2	202.0	36.5
Total	6	25	25	67	123	20.2	443.6	80.1
Survey Area (m^2)	180	150	150	130	610			
Fish / 100 m^2	3.3	16.7	16.7	51.5	20.2			

During the dive survey, surf perch were the most abundant species on the reef. Striped perch were estimated to be the second most common species followed by quillback rockfish, kelp greenlings, copper rockfish, and lingcod.

Surf perch were almost always observed in schools of about six individuals on the reef. Each school consisted of fish ranging from ten to thirty cm in length. Striped perch were observed swimming in groups of five to ten fish. The striped perch in each group ranged from five to fifteen cm in length. Of the nine quillback rockfish observed, two were juveniles, averaging thirteen cm in length, and seven were adults of about twenty-five cm. All of the adult quillback rockfish were observed in crevices while one of the juveniles observed was found in a crevice and while the other was observed swimming over the reef. All of the sixteen kelp greenlings observed were adults of about twenty-five to thirty cm in length. The only copper rockfish observed was an adult of twenty-five cm in length. The two lingcod observed were adults ranging from fifty to fifty-five cm in length.

During the September 1991 survey, of the total fish estimated on the reef, 20% were neritic fish while 80% were benthic fish.

Day dive fish biomass estimates for the French Creek artificial reef are provided in Table 14.
During the dive survey, kelp greenling accounted for the largest fish biomass. Quillback rockfish represented the second greatest biomass followed by lingcod, striped perch, surf perch, and copper rockfish.

In summary, two species of perch, Family Embiotocidae, account for 68.5% of the reef fish population but only 10% of the biomass. Of the three species of perch, surf perch were the most abundant numerically, accounting for 36.5% of the total reef fish population and accounting for only 4% of the total fish biomass. Striped perch account for 32% of the total reef fish population and 4.5% of the total biomass. Two species of greenlings, Family Hexagrammidae, accounted for 13% of the reef fish population but accounted for 80% of the fish biomass on the reef. Of the two species of greenlings, kelp greenlings were the most numerous providing 9.8% of the total reef fish population and 72% of the total fish biomass while lingcod accounted for only 1.3% of the total fish population and 8.0% of the total fish biomass. Quillback rockfish account for 16.5% of the total reef fish population and 9.5% of the total fish biomass. Copper rockfish accounted for only 2.0% of the reef fish population and only 1.9% of the reef fish biomass.

Table 14. September 1991
Day Dive Fish Biomass Estimates for the French Creek Artificial Reef

Fish Type	Estimated Total On Reef	Average Size (cm)	Average Weight (kg)	Total Biomass (kg)	% of Total Biomass On Reef
Rockfish					
Juvenile Copper Rockfish	0	10	0.02	0.0	0.0
Adult Copper Rockfish	11	30	0.34	3.7	1.9
Juvenile Quillback Rockfish	14.6	15	0.05	0.7	0.4
Adult Quillback Rockfish	77	25	0.23	17.7	9.1
Greenlings					
Adult Lingcod	7.2	60	2.15	15.5	8.0
Kelp Greenling	65.1	60	2.15	140.0	71.9
Perch					
Striped Perch	176.7	15	0.05	8.8	4.5
Surf Perch	202	10	0.04	8.1	4.2
Total	553.6	-	-	194.5	100.0

Note: Average weights for perch were calculated using data from Walton (1979).
Average weights for rockfish, greenlings, and sculpins were calculated using formulas provided by C. Hand (Dept. Fisheries and Oceans, pers. comm.).

3.2.2 Macroinvertebrates

Macroinvertebrate reef population estimates were calculated from the transect surveys using the area density method where the number of macroinvertebrates on the reef = (the area of the entire reef) x (the number of macroinvertebrates counted along the transects / the area of the transects).

Note that the French Creek artificial reef was not surveyed for macroinvertebrates during the September 1991 survey.

November 1987 Day Survey

A summary of the day survey macroinvertebrate observations by transects and species is presented in Table 15.

Seastars were the most abundant large invertebrates on the reef outnumbering all other macroinvertebrates observed in each transect. The most abundant seastar species was the ochre star (Pisaster ochraceus) followed by the leather star (Dermasterias imbricata), the short spined star (Pisaster brevispinus), and the morning sunstar (Solaster dawsoni).

The second most abundant macroinvertebrate type on the reef were crabs. The most abundant crab species observed was the northern kelp crab (Pugetta producta) followed by the red rock crab (Cancer productus).

Other macroinvertebrate types noted included numerous bivalves, nudibranchs, anemones, chitons, sea cucumbers, snails, sea urchins and sea squirts.

March 1988 Day Survey

A summary of the day survey macroinvertebrate observations by transect and species is presented in Table 16.

Seastars were the most abundant large invertebrates on the reef during the survey. The most abundant seastar species was the leather star followed by the ochre star, the short spined star, and the morning sunstar.

The second most abundant macroinvertebrate type on the reef were painted tealia anemones (Tealia crassicornis) followed by northern kelp crabs and California sea cucumbers (Parastichopus californicus).

Table 15. November 1987

Day Dive Invertebrate Species Counts at the French Creek Artificial Reef

	Baseline Distance (m)								Total	Invert./	Estimated	% of Total
	20	30	40	50	60	70	80	88	Observed	100 m^2	Total On Reef	On Reef
Anemones												
Painted Tealia	0	0	0	0	0	0	2	3	5	0.6	14.2	3.1
Chitons												
Lined Chiton	0	0	0	0	0	0	0	2	2	0.3	5.7	1.2
Snails												
Blue Top Snail	0	0	0	0	0	0	0	1	1	0.1	2.8	0.6
Nudibranchs												
False Sea Lemon	1	1	1	0	0	0	0	1	4	0.5	11.3	2.5
Bivalves												
Rock Oyster	0	5	0	0	0	0	1	0	6	0.8	17.0	3.7
Rock Scallop	0	0	0	0	0	0	0	1	1	0.1	2.8	0.6
Crabs												
Northern Kelp Crab	2	1	0	3	0	1	2	11	20	2.6	56.6	12.4
Red Rock Crab	0	0	0	0	0	0	0	1	1	0.1	2.8	0.6
Seastars												
Leather Star	5	6	4	4	2	5	0	2	28	3.6	79.3	17.4
Morning Sunstar	0	5	1	4	0	1	1	1	13	1.7	36.8	8.1
Ochre Star	3	9	12	8	4	5	3	4	48	6.2	135.9	29.8
Short Spined Star	3	5	5	10	1	2	1	2	29	3.7	82.1	18.0
Sea Cucumbers												
California Sea Cucumber	0	0	0	0	0	0	2	0	2	0.3	5.7	1.2
Sea Urchins												
Red Sea Urchin	1	0	0	0	0	0	0	0	1	0.1	2.8	0.6
Total	15	32	23	29	7	14	12	29	161	20.7	455.9	100.0
Survey Area (m^2)	121	121	96	133	96	84	84	42	777			
Invert. / 100 m^2	12.4	26.4	24.0	21.8	7.3	16.7	14.3	69.0	20.7			

Table 16. March 1988
Day Dive Invertebrate Species Counts at the French Creek Artificial Reef

	Baseline Distance (m)					Total	Invert/	Estimated	% of Total
	20	30	50	60	70	Observed	100 m^2	Total On Reef	On Reef
Anemones									
Painted Tealia	0	2	0	3	1	6	1.1	23.7	16.7
Crabs									
Northern Kelp Crab	0	1	0	2	0	3	0.5	11.9	8.3
Seastars									
Leather Star	3	4	2	2	1	12	2.2	47.5	33.3
Morning Sunstar	0	0	1	0	0	1	0.2	4.0	2.8
Ochre Star	6	0	2	0	0	8	1.4	31.7	22.2
Short Spined Star	0	2	2	0	2	6	1.1	23.7	16.7
Sea Cucumbers									
California Sea Cucumber	0	0	0	0	0	0	0.0	0.0	0.0
Total	9	9	7	7	4	36	6.5	142.4	100.0
Survey Area (m^2)	120	120	128	100	88	556			
Invert. / 100 m^2	7.5	7.5	5.5	7.0	4.5	6.5			

December 1988 Day Survey

A summary of the day survey macroinvertebrate observations by transect and species is presented in Table 17.

Seastars were again the most abundant of the large invertebrates counted on the reef during the survey. Leather stars were found in the largest numbers followed by short spined stars and morning sunstars.

The second most abundant macroinvertebrate type on the reef were the sea lemon nudibranchs (Archidoris montereyensis) followed by northern kelp crabs and purple sea urchins (Strongylocentrotus purpuratus).

June 1991 Day Survey

A summary of the day survey macroinvertebrate observations by transects and species is presented in Table 18.

Crabs were estimated to be the most abundant large invertebrate on the reef. The most abundant crab species observed was the northern kelp crab followed by the red rock crab.

The second most abundant large invertebrates on the reef were estimated to be crabs. The most abundant seastar species was the leather star followed by the ochre star, the short spined star and the sunflower sunstar.

Other macroinvertebrate types noted include sea cucumbers and sea urchins.

Table 17. December 1988
Day Dive Invertebrate Species Counts at the French Creek Artificial Reef

	Baseline Distance (m)				Total	Invert/	Estimated	% of Total
	10	30	50	70	Observed	100 m^2	Total On Reef	On Reef
Crabs								
Northern Kelp Crab	1	0	0	0	1	0.4	9.6	4.2
Nudibranchs								
Sea Lemon	0	1	1	0	2	0.9	19.3	8.3
Seastars								
Leather Star	3	4	1	2	10	4.4	96.5	41.7
Morning Sunstar	1	1	1	1	4	1.8	38.6	16.7
Short Spined Star	3	1	1	1	6	2.6	57.9	25.0
Sea Urchins								
Purple Sea Urchin	1	0	0	0	1	0.4	9.6	4.2
Total	9	7	4	4	24	10.5	231.6	100.0
Survey Area (m^2)	60	60	64	44	228			
Invert. / 100 m^2	15.0	11.7	6.3	9.1	10.5			

Table 18. June 1991
Day Dive Invertebrate Species Counts at the French Creek Artificial Reef

	Baseline Distance (m)				Total	Invert/	Estimated	% of Total
	20	40	50	70	Observed	100 m^2	Total On Reef	On Reef
Crabs								
Northern Kelp Crab	4	3	2	1	10	4.3	95.2	43.5
Red Rock Crab	0	0	1	0	1	0.4	9.5	4.3
Seastars								
Ochre Star	0	0	1	1	2	0.9	19.0	8.7
Leather Star	0	3	2	0	5	2.2	47.6	21.7
Sunflower Star	0	0	1	0	1	0.4	9.5	4.3
Short Spined Star	1	0	0	0	1	0.4	9.5	4.3
Sea Urchins								
Green Sea Urchin	1	0	0	0	1	0.4	9.5	4.3
Sea Cucumbers								
California Sea Cucumb	0	2	0	0	2	0.9	19.0	8.7
Total	6	8	7	2	23	10.0	219.0	100.0
Survey Area (m^2)	60	50	70	51	231			
Invert. / 100 m^2	10.0	16.0	10.0	3.9	10.0			

3.2.3 Macroalgae

Note that the French Creek artificial reef was not surveyed for macroalgae during the September 1991 survey.

November 1987 Day Survey

A summary of the day survey macroalgae observations are presented in Table 19.

Red algaes (Class Rhodophyceae) were the most abundant of the macroalgaes observed on the reef during the November 1987 day survey. The green algae (Class Chlorophyceae) Ulva spp. and the brown algae (Class Phaeophyceae) Fucus spp. were also found on the reef but only on transects intersecting the intertidal zone.

March 1988 Day Survey

A summary of the day survey macroalgae observations are presented in Table 20.

Red algaes were the most abundant group of macroalgaes observed on the reef during the March 1988 survey. Brown algaes were well represented on the reef as well. The majority of the brown algaes noted were the kelps, Costaria costata and Laminaria saccharina). No green algaes were observed during the March 1988 survey.

December 1988 Day Survey

A summary of the day survey macroalgae observations are presented in Table 21.

The most abundant macroalgae class observed on the reef during the December 1988 survey were, as during the March 1988 survey, the reds. Many individual brown algaes were also seen. No green algaes were observed during the December 1988 survey.

June 1991 Day Survey

A qualitative survey of macroalgae was performed in June 1991. A summary of the day survey macroalgae observations are presented in Table 22.

The most abundant macroalgae class observed on the reef during the June 1991 survey were, as during the March 1988 and the December 1988 survey, the reds. Some brown algaes were observed and no green algaes were observed during the June 1991 survey.

Table 19. November 1987
Day Dive Macroalgae Species
Observed on the French Creek Artificial Reef

Depths Are In Metres Below Zero Tide (Chart Datum)

Algal Species	Observed Depth Range (m)	Average % Cover In Depth Range
Green Algaes		
Ulva spp.	5 - 7	<5
Brown Algaes		
Fucus spp.	1 - 2	<5
Red Algaes		
Corallina spp.	4 - 7	20
Iridea spp.	4 - 6	<5
Laurencia spectabilis	4 - 7	10
Mastocarpus spp.	4 - 7	10
Neoagarhiella baileyi	4 - 7	10
Porphyra perforata	6 - 7	10

Table 20. March 1988
Day Dive Macroalgae Species
Observed on the French Creek Artificial Reef

Depths Are In Metres Below Zero Tide (Chart Datum)

Algal Species	Observed Depth Range (m)	Average % Cover In Depth Range
Green Algaes		
None Observed	-	0
Brown Algaes		
Costaria costata	4 - 7	15
Desmarestia intermedia	1 - 2	<5
Laminaria saccharina	4 - 7	15
Sargassum japonica	1 - 2	<5
Red Algaes		
Neoagarhiella spp.	1 - 2	10
Callophyllis spp.	4 - 5	10
Iridea spp.	4 - 6	15
Mastocarpus spp.	4 - 7	20
Polyneura spp.	6 - 7	15

Table 21. December 1988
Day Dive Macroalgae Species
Observed on the French Creek Artificial Reef

Depths Are In Metres Below Zero Tide (Chart Datum)

Algal Species	Observed Depth Range (m)	Average % Cover In Depth Range
Green Algaes		
None Observed	-	0
Brown Algaes		
Laminaria saccharina	4 - 5	10
Sargassum japonica	1 - 2	10
Red Algaes		
Callophyllis spp.	4 - 7	10
Iridea spp.	4 - 6	10
Mastocarpus spp.	4 - 7	20
Microcladia spp.	4 - 7	10
Necagarhiella baileyi	6 - 7	10

Table 22. June 1991
Day Dive Macroalgae Species
Observed on the French Creek Artificial Reef

Algal Species Present (Qualitative Observations)

Green Algaes
None Observed

Brown Algaes
Costaria costata
Sargassum muticum

Red Algaes
Corallina vancouveriensis
Iridea spp.
Laurencia spectabilis
Mastocarpus spp.
Microcladia spp.
Neoagarhiella baileyi
Porphyra perforata
Rhodymenia pertusa

3.3 Diel Changes

3.3.1 Fish

A summary of diel changes in fish abundance on the artificial reef at French Creek, B.C. as observed in November 1987 is presented in Table 23.

The total fish population and total fish biomass on the reef was estimated to be higher at night than during the day. In most cases the number and biomass estimated for each species of fish enumerated was also higher at night. The exceptions were striped perch, which decreased in abundance at night and increased in biomass during the day, and juvenile kelp greenlings, painted greenlings, shiner perch, and juvenile lingcod, which were observed during the day but not at night. Those fish species, which showed an estimated increase in biomass on the reef at night, were not always present in correspondingly higher numbers at night. For juvenile copper rockfish, striped perch, and surf perch the increase in biomass from day to night was many times greater than the increase in numbers of individuals counted during the same time period. This suggests that for the three species observed the fish were larger at night than during the day.

Some species of fish on the reef exhibited different behaviour at night compared with the day. During the day rockfish were almost always observed in crevices on the reef, whereas at night they were observed both hiding in crevices and swimming over the reef in small schools. Striped perch and surf perch were observed schooling over the reef during the day while at night these two species were seen both hiding in crevices and swimming over the reef. Striped perch were found in large schools during the day and as solitary individuals or in very small schools at night. Of the total number of fish estimated on the reef, 24% were neritic at night compared with 76% during the day while 76% exhibited benthic behaviour at night compared with 24% during the day. The diel shift in the percentage of neritic versus benthic fish was due mainly to a behaviour shift exhibited by the perch, which were observed swimming over the reef during the day but moved into crevices at night. Walton (1979) suggests that this fish movement into crevices facilitates hiding from larger piscivorous fish which are more active at night.

3.3.2 Macroinvertebrates

A description of diel changes in the pattern and degree of abundance of invertebrates on the artificial reef at French Creek is beyond the scope of this report. It is reasonable to assume, however, that there could have been diel changes in the behaviour of some invertebrates on the reef. For example, in August 1987, a Pacific octopus (Octopus dofleini) was observed during a night SCUBA dive but was not observed during a day dive on the same date.

Table 23. November 1987
Diel Changes in Fish At The French Creek Artificial Reef.

	Total On Reef		Fish / 100 m^2		Average Size (CM)		C=Crevice or S=Swimming		Total Biomass On Reef (kg)	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Large Sculpins	5.6	33.1	0.2	1.6	20	17.5	C	C	0.8	4.8
Rockfish										
Juvenile Copper Rockfish	53.8	265.9	2.4	12.1	10	15	C	CS	1.1	18.6
Adult Copper Rockfish	11.3	238.0	0.5	10.8	30	25	C	CS	3.8	64.3
Juvenile Quillback Rockfish	5.7	40.6	0.3	1.8	15	15	C	CS	0.3	2.0
Adult Quillback Rockfish	2.8	44.3	0.1	2.0	25	25	C	C	0.6	10.2
Greenlings										
Juvenile Kelp Greenling	8.5	0.0	0.4	0.0	20	-	C	-	0.4	0.0
Adult Kelp Greenling	5.7	38.8	0.3	1.8	30	30	C	C	1.1	9.3
Juvenile Lingcod	1.2	0.0	0.1	0.0	30	-	S	-	0.3	0.0
Adult Lingcod	4.6	7.4	0.2	0.3	60	60	S	S	9.9	15.9
Painted Greenling	5.7	0.0	0.3	0.0	30	-	C	-	1.4	0.0
Perch										
Shiner Perch	1.2	0.0	0.1	0.0	10	-	S	-	0	0.0
Striped Perch	288.2	114.3	13.1	5.2	15	25	S	CS	14.4	26.6
Surf (Pile) Perch	24.3	96.1	1.1	4.3	10	20	S	CS	1	17.3
	Total		Total		Average				Total	
	418.5	878.7	19.0	39.9	23.5	17.9			35.1	171.0

3.4 Seasonal Changes

A detailed investigation of the seasonal changes in the biological characteristics of the artificial reef at French Creek is beyond the scope of this report. However, some general observations for fish, macroinvertebrates, and macroalgae follow.

3.4.1 Fish

A summary of changes in fish presence and abundance on the artificial reef at French Creek as observed during day surveys in November 1987, March 1988, December 1988, June 1991, and September 1991 is presented in Table 24.

Total fish numbers on the French Creek artificial reef were estimated to be highest in the winter and lowest in the summer. The percentage of the total number of fish on the reef estimated to be benthic was lowest in the winter and highest in the summer while the percentage estimated to be neritic was highest in the winter and lowest in the summer.

Of the total benthic fish on the reef the percentage of rockfish was highest in the summer and lowest in the winter and spring and the percentage of greenlings was highest in the fall and lowest in the winter, spring, and summer.

Of the total neritic fish on the reef the percentage of rockfish and lingcod were highest in the summer and lowest in the winter while the percentage of striped perch was lowest in the summer and highest in the winter and spring and the percentage of surf perch was highest in the fall and lowest in the winter.

Note that, although the November and December surveys in this report occurred over a year apart, the presence of rockfish during the month of November and the absence of rockfish during the month of December may indicate that rockfish migrate off the reef during a short period of time in early winter. Qualitative observations made at artificial reefs in the Nanaimo, British Columbia area since 1988 corroborate this theory of rapid rockfish migration (B. Naito, pers.comm.).

Table 24. Seasonal Changes In Fish At The French Creek Artificial Reef

	March 1988	June 1991	September 1991	November 1987	December 1988
Total Fish Numbers	278.5	123.8	553.6	418.5	649.7
Cryptic %	2.8	53.9	19.9	23.7	0.0
Swimming %	97.2	46.2	80.1	76.3	100.0
Total Cryptic Fish	7.9	66.7	110.0	99.1	0.0
Rockfish %	0.0	100.0	90.0	74.3	0.0
Greenlings %	0.0	0.0	10.0	20.1	0.0
Other %	100.0	0.0	0.0	5.7	0.0
Total Swimming Fish	270.6	57.1	443.6	319.4	649.7
Rockfish %	0.0	11.5	0.1	0.0	0.0
Lingcod %	0.6	7.6	0.0	1.8	0.0
Striped Perch %	84.8	7.7	39.8	90.2	99.0
Surf (Pile) Perch %	14.6	19.2	45.5	7.6	0.0
Other %	0.0	0.0	12.2	0.4	0.5
Total Fish Biomass (kg)	17.8	27.1	194.5	35.2	39.9
Cryptic %	7.3	40.0	23.5	27.0	0.0
Swimming %	92.7	60.0	76.5	72.7	100.0
Total Cryptic Fish (kg)	1.3	11.0	45.6	9.5	0.0
Rockfish %	0.0	11.0	48.0	61.1	0.0
Greenlings %	0.0	0.0	52.0	30.5	0.0
Other %	100.0	0.0	0.0	8.4	0.0
Total Swimming Fish (kg)	16.5	16.3	148.9	25.6	39.9
Rockfish %	0.0	20.2	0.0	0.0	0.0
Lingcod %	20.6	70.6	10.4	39.8	18.0
Striped Perch %	69.7	3.1	5.9	56.3	80.7
Surf (Pile) Perch %	9.7	6.1	5.4	3.9	0.0
Other %	0.0	0.0	78.1	0.0	1.3

3.4.2 Macroinvertebrates

A detailed description of seasonal changes in the pattern and relative abundance of macroinvertebrates on the artificial reef at French Creek is beyond the scope of this report. In general, however, seastars were observed to be the most conspicuous and estimated to be the most abundant macroinvertebrate on the reef during the three daylight surveys.

3.4.3 Macroalgae

A detailed description of seasonal changes in the pattern and abundance of macroalgae on the artificial reef at French Creek is beyond the scope of this report. In general, however, during all surveys, red algaes were the most abundant in terms of percent cover.

4.0 ACCURACY OF TRANSECT METHODS

The accuracy of the transect method used during the biological surveys of the French Creek artificial reef is highly dependent on the behaviour of the fish and invertebrates observed.

Due to the physical complexity of the reef some of the fish and invertebrates hidden in crevices may have been overlooked during the transect surveys. Density and population estimates, therefore, may have been underestimated for cryptic benthic fish and invertebrates. Neritic fish, which were counted, may have moved laterally and ahead of the divers in each transect (e.g. perch schools occasionally followed the divers) or could have moved to other transects (e.g. lingcod which exhibited diver avoidance). This movement by fish could have led to double counting and overestimation of densities and populations. If the fish were frightened entirely off the reef before they were counted, an underestimate of densities and population would have occurred.

A method of determining the accuracy of fish and invertebrate census techniques used in these surveys was not developed for this study.

5.0 DISCUSSION

As of the November 1987 survey the artificial reef at French Creek, B.C. was over four years old. Marine life has become well established during those four years. The fish community on the reef is abundant and represents individuals from all size classes. The large numbers of juvenile fish indicates that the reef may be used as a nursery area. The invertebrate and algal communities were also abundant. The abundance of fish, invertebrates, and algae suggests that the success of the French Creek artificial reef provides valuable marine fish habitat.

The results detailing the diel variability in fish density, biomass, and size on the French Creek artificial reef were similar to results obtained by Hueckel (1980) and Walton (1979). In the study by Walton (1979) fish densities, biomass, and size were generally greater during the night than during the day. Hueckel (1980) also found that fish on the reef were larger at night than during the day and suggested that large perch and rockfish vacate artificial reefs during the day and return to the reefs at night to forage.

The results relating to seasonal changes in fish density and biomass on the French Creek artificial reef are similar to the findings of other studies. The occurrence of rockfish on artificial reefs has been documented to be seasonal by Matthews (1990a), Matthews (1990b), Hueckel et al. (1983), Walton (1979), and Moulton et al. (1974). Hueckel et al. (1983) and Walton (1979) both found that fish densities on artificial reefs were highest during the fall and early winter and lowest during spring and summer. Moulton et al. (1974) found that rockfish were nonexistent or very few in number on reefs during the late winter and early spring and suggested that rockfish move off the reefs to deeper water during this time period. Matthews (1990a) and Matthews (1990b) found that rockfish densities on artificial reefs peaked in the fall and early winter and were lowest in the summer.

Seasonal changes in macroinvertebrates and macroalgae on artificial reefs has not been well documented. Further studies on artificial reefs should include the relationship between the seasons and invertebrates and algae densities.

The practice of placing artificial reefs on 'unproductive' sandy bottoms to modify the profile of an otherwise featureless bottom is an accepted and proven technique used throughout the world to attract recreationally important bottomfish (Steimle and Stone, 1972). Although the flat sand bottom around the artificial reef at French Creek was not quantitatively studied, visual observations indicate that the number of species, density, and biomass, of fish were lower on the neighbouring sand seabed than on the reef. In other words, the placement of the reef on the nearshore marine sand environment at French Creek resulted in an increase in the number of species of fish and their density and biomass on the sand environment also increased.

Although the artificial reef at French Creek was a success in terms of the number of different fish species represented, their density, and biomass it is important to realize the possible ecological implications of reef placement on 'barren' habitat. Walton (1979) suggests that sand bottoms may be productive in terms of juvenile fishes, clams, shrimps, and/or other invertebrates (e.g. benthic invertebrates). Besides the burial of some individuals, the introduction of new predators associated with the reefs could deplete other valuable fish species. For example, the placement of reefs along the migration routes of juvenile salmonids may introduce new predators to these valuable commercial and recreational species.

6.0 REFERENCES

Brock, V.E. 1954. A preliminary report on a method of estimating reef populations. J. Wildl. Mgmt. 18(3):297-308.

Harbo, R.M. 1980. Tidepool & Reef. Marine Guide to the Pacific Northwest Coast. Hancock House. N. Vancouver, B.C. 57pp.

Hueckel, G.J. 1980. Foraging on an artificial reef by three Puget Sound fish species. Wash. Dept. Tech. Rept. No. 53: 110pp.

Hueckel, G.J., R.M. Buckley and B.L. Benson. 1983. The biological and fishery development on concrete habitat enhancement structures off Gedney Island in Put Sound, Washington. Wash. Dept. Fish. Tech. Rept. No. 78: 67pp.

Lamb, A. and P. Edgell. 1986. Coastal Fishes of the Pacific Northwest. Harbour Publishing. Madiera Park, B.C. 224pp.

Matthews, K.R. 1990a. An experimental study of the habitat preferences and movement patterns of copper, quillback, and brown rockfishes (Sebastes spp.). Envir. Biol. 29:161-178.

Matthews, K.R. 1990b. A comparative study of habitat use by young-of-the-year, subadult, and adult rockfishes on four habitat types in central Puget Sound. F sh. Bull. 88(2):223-239.

Moulton, L.L., B.S. Miller, and R.I. Matsuda. 1974. Ecological survey of demersal fishes at Metro's West Point and Alki Point outfalls, January - December 1973. Sea grant Publ. WSG-TA: 74-81.

Naito, B.G. 1988. An assessment of the French Creek artificial reef. Unpublished report submitted to Public Works Canada, Vancouver, B.C. March 1988. 22pp.

Naito, B.G. 1987. An assessment of the French Creek artificial reef. Unpublished report submitted to Public Works Canada, Vancouver, B.C. November 1987. 26pp.

Richards, L.J., J. Paul, A.J. Cass, L. Fitzpatrick, R. Van Den Broek, and C. Lauridsen. 1985. SCUBA survey of rockfish assemblages in the Strait of Georgia, July to October 1984. Can. Data Rept. Fish. Aquat. Sci. 545:91pp.

6.0 REFERENCES (cont'd)

Scagel, R.F. 1967. Guide to Common Seaweeds of British Columbia. Queen's Printer. Victoria, B.C. 330pp.

Steimle, F. and R.B. Stone. 1972. Bibliography on artificial reefs. Coastal Plains Ctr. For Mar. Dev. Serv. Wilmington, N.C. 128pp.

Walton, J.M. 1979. Puget Sound artificial reef study. Wash. Dept. Fish. Tech. Rept. No. 50: 130pp.

APPENDIX I. Species List For Fish Observed At The French Creek Artificial Reef.

Common Name	Scientific Name
Sculpins	
Brown Irish Lord	Hemilepidotus spinosus
Cabezon	Scorpaenichthys marmoratus
Grunt Sculpin	Rhamphocottus richardsoni
Red Irish Lord	Hemilepidotus Hemilepidotus
Rockfish	
Copper Rockfish	Sebastes caurinus
Quillback Rockfish	Sebastes maliger
Perch	
Shiner Perch	Cymatogaster aggregata
Striped Perch	Embiotoca lateralis
Surf (Pile) Perch	Rhacochilus vacca
Greenlings	
Kelp Greenling	Hexagrammus decagrammus
Lingcod	Ophiodon elongatus
Painted Greenling	Oxyiebius pictus

APPENDIX II. Species List For Invertebrates Observed At The French Creek Artificial Reef.

Common Name	Scientific Name
Anemones	
Painted Tealia	Tealia crassicornis
Chitons	
Lined Chiton	Tonicella lineata
Snails	
Blue Top Snail	Calliostoma ligatum
Moon Snail	Polinices lewisii
Nudibranchs	
False Sea Lemon	Archidoris montereyensis
White-lined Nudibranch	Dirona albolineata
Bivalves	
Rock Oyster	Pododesmus macroschisma
Rock Scallop	Hinnites giganteus
Barnacles	
Acorn Barnacle	Balanus glandula
Crabs	
Northern Kelp Crab	Pugetta producta
Red Rock Crab	Cancer productus
Seastars	
Blood Star	Henricia leviuscula
Ochre Star	Pisaster ochraceus
Leather Star	Dermaster imbricata
Morning Sunstar	Solaster dawsoni
Short Spined Star	Pisaster brevispinus
Sunflower Star	Pycnopodia helianthoides
Sea Cucumbers	
California Sea Cucumber	Parastichopus californicus
Sea Urchins	
Red Sea Urchin	Strongylocentrotus franciscanus
Purple Sea Urchin	Strongylocentrotus purpuratus
Sea Squirts	
Broad Based Sea Squirt	Cnemidocarpa finmarkiensis